

DOCUMENT RESUME

ED 147 692

CG 012 015

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TITLE A Learning Model for Updating Older Technical and Professional Persons.
PUB DATE Aug 77
NOTE 38p.; Paper presented at the Annual Meeting of the American Psychological Association (San Francisco, California, August 26-30, 1977)
EDRS PRICE MF-\$0.83 HC-\$2.06 Plus Postage.
DESCRIPTORS Adult Education; *Continuous Learning; Educational Attitudes; Knowledge Level; Learning Motivation; Models; *Professional Continuing Education; *Professional Personnel; *Skill Obsolescence; *Technical Occupations; Technological Advancement; Work Environment
IDENTIFIERS *Experiential Learning; *Personnel Updating

ABSTRACT

Technical and professional persons are especially threatened by the potentiality of becoming outdated in their skills and their knowledge. It is not enough for workers in these fields to maintain the competence acquired in the years of formal education. Their information bank is anything but static; the norm is perpetual change. Psychologists, scientists and engineers have no choice but to plan for a life of continuous self-education and self-renewal by keeping abreast of new developments and new knowledge which are constantly being generated by research. Keeping current with new developments in science and technology is what we refer to as updating. The reverse of updating is obsolescence. This paper describes a model for keeping older technical and professional persons updated. The model emphasizes the experiential mode of learning, which is more suited to adults. Experiential learning has the following characteristics: (1) it defines the teacher's role as one of learning facilitator rather than director of instruction; (2) it focuses on attitudes and skills which foster continuing education; (3) it emphasizes an active process rather than a passive one; and (4) it stresses self-initiated learning. (Author)

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ED147692

A Learning Model for Updating Older Technical and Professional Persons

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TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."

Presented at The American Psychological Association
San Francisco, California
August 25-30, 1977

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ABSTRACT

During the working years of a technical and professional person, roughly between the ages of 25 and 65, a critical issue is whether he or she can maintain a high level of competence against the eroding effect of the passage of time. Technical and professional persons are especially threatened by the potentiality of becoming outdated in their skills and their knowledge. It is not enough for workers in these fields to maintain the competence acquired in the years of formal education. Their information bank is anything but static; the norm is perpetual change. Psychologists, scientists and engineers have no choice but to plan for a life of continuous self-education and self-renewal by keeping abreast of new developments and new knowledge which are constantly being generated by research.

Keeping current with new developments in science and technology is what we refer to as updating. The reverse of updating is obsolescence. In this paper I propose to describe a model for keeping older technical and professional persons updated.

The model emphasizes the experiential mode of learning which is more suited to adults. Experiential learning has the following characteristics: the teacher role is one of learning facilitator rather than a director of instruction; it focuses on attitudes and skills which foster continuing education; it emphasizes an active process rather than a passive one; it stresses self initiated learning.

During the past two decades professional updating in engineering and science has increasingly become a topic of concern. Behind this emerging concern are two pressures: the growth of specialized knowledge and the state of environmental flux in contemporary organizations. Environmental flux, according to Hinrichs (1971), "is evident in the increasing complexity of current technologies and organizations, the changes taking place in our society, and the many ambiguities faced by decision makers in our society. High levels of skills, broad perspectives, flexibility and competence in the leading edge of the appropriate technology are the hallmarks of successful enterprise in today's environment. This implies a need for professional updating."

Updating is a learning process. Learning is basically change. It is a complex growth process facilitated by numerous factors, among which the most important are motivation, meaningfulness, reinforcement, generalization, participation, coaching, experience and feedback of results. Updating is a dependent variable resulting from a combination of psychological and work environment conditions. In the updating model presented here motivation is the chief psychological component. But an individual's motivation is strongly influenced by his work environment. In the context of our model, work environment is described as consisting of five components: organizational climate, the work itself, managerial subordinate relationships, colleague interaction, and management policy. It is assumed, therefore, that all these factors in the work environment will have some impact on the learning process which is updating either independently or in combination (Dubin, 1974a,b; 1972a,b,c). Figure 1 shows the multiplicative aspects of the updating process.

Insert Figure 1

$$P(U) = f(M, W.E.)$$

$P(U)$ = Probability of Updating

M = Individual Motivation

$W.E.$ = Work Environment

$$W.E. = W_1 (O.C.) + W_2 (J.C.) + W_3 (S.S.) + W_4 (C.I.) + W_5 (M.P.)$$

$W_1 \text{---} W_5$ = Weight Assigned to Each Variable

$O.C.$ = Organizational Climate

$J.C.$ = Job Characteristics

$S.S.$ = Supervisor-Subordinate Relationships

$C.I.$ = Colleague Interactions

$M.P.$ = Management Policy

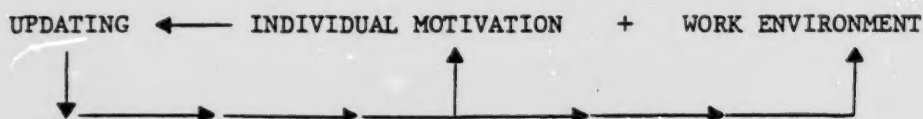


Figure 1. The Updating Model

Definition of Keeping Up-To-Date

When we speak of keeping up-to-date in one's profession we refer to such behaviors as making use of current concepts, practices, theories and points of view in both one's field and allied fields which bear on the work of one's organization. Keeping up-to-date also means being familiar with what others in the same field are working on, what problems they are trying to solve, what approaches to solutions they are taking (NSF, 1969). This definition requires that the professional be conversant with the latest technological developments in his field and that he be able to use recently developed techniques to solve problems assigned to him. It assumes that he has not overlooked significant implications nor neglected significant facts arising from his work. Being current in his field enables him to translate theory into practice. He is capable of detecting new features in an environment and of responding to them effectively.

In summary, we describe the updated professional as showing the following behaviors: keeps current with advanced technology and knowledge in his field; effectively organizes and applies his knowledge in the performance of his work; is current in recent developments outside his special field; uses all available sources of information in reaching decisions; provides information that is accurate and reliable; contributes ideas relating to activities outside his immediate responsibility; demonstrates ingenuity in solving problems and seeks methods and means of continuously improving his proficiency.

Self-Motivation for Updating

Most technical and professional persons, especially those engaged in R&D work, are aware that keeping current with new technology and information is essential for maintaining professional competence. Only a minority of highly-trained professionals hold the opinion that the idea of rapid obsolescence in scientific and technological skills and knowledge is being overplayed (Dubin, 1975). Recognition that there is a problem--that knowledge is a perishable commodity--is the first step in the direction of updating.

The individual's motivation to update is a corollary to his motivation to perform well. Generally speaking, the same motivators which spur him to improve his performance are those which motivate him to update. Some of the behaviors which are recognized as motivators are: interest and curiosity, achievement need, advancement, challenge, recognition, autonomy, and responsibility. These can be classified as intrinsic or self-motivators arising from the individual's personality and personal needs, as distinguished from extrinsic or external motivators which arise from outside the individual, or, in this case, from the work environment. Motivational factors arising from the work environment will be considered later.

It should be pointed out that while motivation is undoubtedly an important variable in updating behavior, only a few motivation studies have been made to date which relate directly to updating per se.

The close parallel between the motivation to perform well and the motivation to update is evident in responses by scientists and engineers themselves in answer to the question: What motivates you in your work?

The most frequent answer is: a challenging problem (Margulies and Raia, 1967). Why? Because it arouses curiosity and interest. It has not been solved. Little information is readily available about it. It requires an innovative solution. It is on the leading edge of knowledge. It can lead to new technological output. It means freedom to explore, carry out my own ideas and initiative (Dubin, 1975). Obviously, the person who wishes to tackle a challenging problem for these reasons is one who needs and desires to keep himself current with the frontier of knowledge in his field.

Shearer and Steger (1975) investigated six dimensions of motivation in relation to keeping up-to-date. Five of the six hypotheses were confirmed.

1. The higher the career expectations, the less obsolescent the person.
2. Individuals who perceive a duty to stay current spend more off-work time in updating activities in their field.
3. People with a future time orientation spend relatively more time after work keeping up-to-date.
4. High achievement need influences behavior to prevent or retard obsolescence.
5. People with strong beliefs that they control their future have an orientation which tends to prevent obsolescence.

The Expectancy Theory of Motivation

The expectancy theory of motivation postulates that motivation consists of a complex combination of individual judgments concerning the accomplishment of job goals and the immediate rewards or outcomes gained from these goal accomplishments. It has practical application to the updating process.

It is a theoretical model of personal motivation which sees an individual as behaving primarily as a function of the rational forces within him. Applied to work motivation, it conceptualizes man as one who chooses to behave in a way which maximizes his chances of acquiring future desired rewards. As a process theory it attempts to explain relationships among variables in a dynamic state. The theory does not specify the important variables which impinge on an individual to create what is called "work motivation." Rather it provides a theoretical structure to describe any cognitively controlled behavior--within any set of individuals--not just professionals. The most important characteristic of expectancy theory is its flexibility, the result of its process nature.

Another approach to understanding the individual's motivation for professional updating was advanced by Porter (1971) making use of expectancy theory. According to Porter, the professional evaluates different kinds of potential rewards and selects that combination of rewards which is most appealing to him. "From the motivational theory standpoint, this would utilize high valences of outcomes to increase each individual's overall motivation to exert effort in this particular direction--engaged in updating activities." Porter presented a number of provocative hypotheses that require testing: it must be clearly demonstrated to the employee that his effort will lead to effective updating performance; subgoals for updating should be set which are obtainable and identifiable for the individual; organizational emphasis should show that updating is an important activity; the reward value of updating behavior should be enhanced by tying it to other more obvious organizational rewards such as promotion and salary.

Hinrichs (1971) reported the results of the application of two theoretical models of motivation--content and process--to the problem of skills updating in a large technology-based organization. He found that higher-order content needs based on Maslow's need hierarchy model were not substantiated. He concluded that the expectancy process model seemed more predictive of skills updating. "The reward system of the organization is the individual's perception of the outcomes that will accrue to him for updating behavior. This is significantly related to the effort which he devotes to updating." McIntyre (1977) relates how expectancy theory can be applied to updating in three ways. First, the theory dictates that an individual's goals should be elicited from the person himself. The same set of goals should never be assumed to be had by all. If management discovers that a professional is not aware of certain potential goals of the organization, it can intervene and make the goals known to him. Second, the organization must determine the importance . . . of a set of goals and the perceived likelihood (expectancy) of the occurrence of a set of goals by probing at the level of the individual professional. Once again the organization may intervene to try to influence an individual's valence or expectancy of a particular goal. Third, because it is a process theory, it allows the organization to be flexible in its outlook towards its professionals. There is no need to establish a specified set of goals and outcomes for all. At the same time, the theory does not invalidate the existence of a set of common goals. Finally, the organization can use expectancy theory as a tool with which to diagnose the individual's obsolescence. The theory provides the organization a means of asking the important questions aimed at the following logical sequence of theoretical concepts: ultimate goals, instrumentality, valence, expectancies, and behaviors. This is the

most valuable aspect of expectancy theory--its ability to stimulate the appropriate set of questions.

Arvey and Noll (1970) utilized expectancy theory to identify motivations in older engineers. They found that the three most valued outcomes out of the eleven measured were: making use of abilities, accomplishments, and secure employment. The three least desirable were: receiving praise, supervising others, and advancement. Salary ranked sixth in importance. These findings identify job outcomes that can potentially turn on older engineers.

Similarly Goodman, Rose and Furcon (1970) showed that the expectancy model was a more useful predictor of motivational determinants of scientific performance than the motivational measures used by Pelz and Andrews (1966).

Goal Setting

Keeping up-to-date can be stimulated through goal-setting activities. Management by objectives is a mutual goal-setting method used between managers and subordinates. The technique aims to elicit commitment and effort. Locke (1968) has demonstrated that individuals who set hard goals will produce at higher levels of performance than individuals who set easy goals; and that individuals who set specific goals produce at higher levels than individuals who do not set goals or who are told to do "their best." In performance appraisal situations, the process of setting down and formulating mutually agreed upon performances and explicit updating goals may increase effort to accomplish the goal of keeping up-to-date.

The MBO program utilizes expectancy theory in combination with goal setting. The very act of setting goals between the manager and his subordinate has built into it the possibility of intrinsic rewards, especially when the goal is met. These two conditions can yield a high effort reward probability for increasing motivation and learning on the job.

Work Environment

The work environment for most professionals is an organization. The climate of the organization in which an individual works can be a positive motivator for updating or it can be a demotivator which ultimately produces obsolete workers.

Organizational Climate

Pritchard and Karasick (1973) redefined organizational climate based on a number of previous definitions: Organizational climate is a relatively enduring quality of an organization's internal environment distinguishing it from other organizations; (a) which results from the behavior and policies of members or organizations, especially top management; (b) which is perceived by members of the organization; (c) which serves as a basis for interpreting the situation; and (d) acts as a source of pressure for directing activity.

Updating behavior by professionals is strongly influenced by the organizational climate in which they work. Organizational and management practices affect motivation, condition attitudes, and shape the behavior of members of the organization (House and Rizzo, 1972). Campbell and Dunnette (1968) have identified a high organizational climate as having some of the following characteristics: (a) achievement--a desire of the group to do a good job and contribute to the performance of the company; (b) concern for excellence--degree to which the group is concerned with improving individual performance, being flexible, innovative and competent; (c) problem-solving emphasis--extent to which the group anticipates and solves problems related to group functioning; (d) reputation--organization reflects status and

reputation of individual's work group as compared with other work groups; (e) training opportunities--degree to which the organization provides training for individuals; (f) atmosphere--degree to which supervisors generate a supportive and friendly atmosphere; (g) initial job orientation--individuals are informed of what to expect when they first start on the job.

Organizational climate is a major factor in maintaining the technical vitality of professional workers. Corporate policies and practices as implemented by management create the working environment. The environment can stimulate growth, innovation, and updated professionals, or it can stunt growth and stifle creative effort so that men work at less than their full potential. A vital organizational climate is characterized by high productivity, sense of purpose among its employees, sense of personal opportunity, feeling of accomplishment and excitement. The climate that offers the potential for recognition and reward, openness to change and new ideas, strong contact with new developments, and outside the organization is one which fosters updating (Dubin, 1975).

Management Policy in Updating

A company should have a written policy statement that requires updating for its employees. An example of such a policy statement is that of the Sandia Laboratories (Appendix I). Many companies have educational assistance funds that reimburse employees who complete education courses, but few companies make continuous updating mandatory. In our study of engineers (Dubin and Marlow, 1965), 79% reported that their companies had educational assistance programs, but three fourths of the engineers reported that this availability had no effect in motivating them to undertake additional course work. Similarly, in a study of natural resource managers and scientists

(George and Dubin, 1971) 52% indicated that existence of a policy on educational assistance did not motivate to undertake further education. Yet 83% of the same group considered keeping up-to-date important and 80% said that their job performance and job competence increased as a result of participation in continuing education. Only 50% of the natural resource managers and scientists felt that the organization rewarded them for their participation in continuing education. The main reasons given for lack of participation in further education are lack of time, pressures of family and the job, and the fact that the job does not demand more education (Dubin and Marlow, 1965)(George and Dubin, 1971).

W. E. Wilson (1969), a vice president at General Motors, warned that "engineers who ignore the meaning of technical obsolescence become technically obsolete, because then they approach problems with outdated viewpoints, theories and techniques." While he stressed that the individual must be basically responsible for his own development and updating, he pointed out that the employer has an equal responsibility to provide the environment and incentive to encourage the engineer that there is a premium put on up-to-date education. "That premium is going up for the man who is fluid enough to adjust to change. We must make the engineer aware of his needs and help him plan to meet them. We must let one engineer know that his one formal brush with education is not going to be enough and that he should expect to reevaluate continually and reeducate himself two or three times in his lifetime." This is an explicit statement of management policy that specifically shares the burden between the individual and the organization. If technical obsolescence is to be minimized then the organization's commitment to the management of change and development of people must have top management approval and implementation.

Anders (1976), a Texas Instrument personnel man, states his company policy: "The company has specific corporate goals and objectives that it must meet. One of these objectives is to create a working environment where all individuals are motivated to participate in the achievement of company goals through the pursuit of their personal goals to the maximum possible extent."

A. G. Anderson (1973), vice president and director of research at IBM, states a management policy aimed to put new life in R&D:

"We appear to be entering a period where emphasis will need to be placed on policies which maintain the intellectual vigor of the staff which is in R&D now. Such policies must address the issues of making the organization better through capitalization on its experience and strength while preserving and extending its vitality. Some individuals will not need help to remain intellectually alive. However, thousands of others would be benefited by policies designed to maintain intellectual vitality. Those policies must address issues of individual and group productivity, intellectual receptivity and openness, broad contact with all pertinent science and technology, and continuing efforts to educate and be educated. The growing strength of R&D outside the U.S. makes the mandatory broad efforts to maintain contact on a worldwide basis."

Anderson proposes to do this through: an extensive visitor policy to provide continual contacts with people with new insights and experiences as consultants, faculty, etc.; aggressive efforts through training to keep people up-to-date; special efforts to insure that organizations provide opportunity to ideas and people, and an organizational policy to develop their best men not only internally but externally.

The NSF (1969) report concludes its study of organizational policies and practices by noting:

The three key points in top laboratory management philosophy of continuing education are: management accepts the responsibility to provide at least some opportunities for scientists and engineers in the R&D work force; management expects R&D employees to keep themselves up-to-date, particularly in their own fields of specialization; and, finally, management accepts only limited responsibility for motivating the individual. Managements which provide opportunities for continuing education believe that those who do not take advantage of them are not worth attempting to salvage. The initiative is left to the individual.

Thompson and Dalton (1976) have formulated a career-stage model in an R&D organization that helps explain the difference between high and low performers at different age levels. A close analysis reveals that the more effective organizations have policies and practices more consistent with the concept of career stages. They identified a number of management policies that have interfered with the updating process and contributed to obsolescence. These are:

Devaluation of the technical contribution of the engineer: "In engineering organizations the reward system is designed to provide an incentive to the brightest people to move out of technical work and into management as fast as possible."

Management structures that overemphasize product planning: "The domination of product planning over career planning contributes to obsolescence. When a project ends engineers find their skills obsolete and unsalable. An obsolete organization is a major cause for creating obsolete engineers."

Cost systems that work against career development.

Inadequate manpower planning.

An organizational approach that facilitates the updating of the personnel is matrix management. Under this dual system each professional has two bosses-- a project or technical manager and a functional manager. The technical manager worries about getting the task completed; the other worries about staffing, job assignments, updating of personnel, etc. The functional manager has the responsibility for the career development of the engineers in his group. If a person has been working in a narrow specialty too long, the functional manager has the power to move him into a new area to help him develop greater breadth. This type of management policy does not leave the updating process to chance; it is integrated into a career development program.

Technical Vitality

Miller's (1977) vitality concept is an experiment in management policy to reward updating. It has as one of its objectives the redesign of the working environment, the work and rewards to improve the performance of scientists and engineers. Its intent is to improve the capacity of the environment to provide learning and growth opportunities and appropriate rewards for growth. These activities enhance updating and minimize obsolescence. Similarly Anderson's (1973) efforts at IBM to put new life into R&D is directed to the redesign of the organization climate dimension.

Miller (1974) uses the term technical vitality as a shorthand way of describing a set of activities designed to help engineers and scientists become more productive. He describes three combined conditions which affect vitality: rapid advances in technology that lead to a form of human obsolescence; slowed personal growth leading to aging in professionals-- which raise questions about the decline in productivity and the need for extending it; reassessment of the value and cost of technological progress-- this creates questions about motivating engineers and the quality of an engineering education. He believes that technical vitality is the key to future productivity of scientists and engineers. Further, he describes the technically vital engineer as one who is able to work effectively at the frontier of his field by contributing both to increasing and applying knowledge that improves equipment and systems.

Miller (1977) has revised his thesis for improving productivity and personal commitment by introducing the quality of life concept. He has broadened considerably the use of the behavioral sciences in attacking both productivity and person commitment by emphasizing the psychological requirements of work as: challenge, greater personal decision involvement, continued stimulation to learn, social support in the work environment, and a job that leads to a desirable future. In this context, he defines vitality as the desire and ability to perform effectively and vigorously in life and at work and to derive personal growth and satisfaction from life and work. The force behind this effort is the condition that management is under pressure to improve output and reduce costs and is simultaneously pushing hard for innovation and new products.

Miller suggests that for the engineer to be turned on to his work he must feel a sense of personal contribution and growth. He suggests a series of steps for improving the working environment and commitment to growth and development:

1. Raise the value and priority of continued learning, growth, and personal vitality in the work environment.
2. Find out what causes engineers to grow throughout life and then provide a better growth environment. This may involve the redesign of organizations, changes in styles in management, and rewards.
3. Define professional productivity and describe its elements in a way that makes it possible for engineering managers to talk about it and manage it.
4. Encourage engineers to increase their self understanding so that each individual can maximize both this contribution to organizational goals and satisfaction he derives from his job.

To accomplish these overall goals, a number of improvement strategies at both the individual and corporate level have been initiated at IBM.

1. Increase the importance of continued learning and growth. To accomplish this goal IBM set up two committees: one to obtain management's understanding and involvement in the problem, and second to elicit specific action proposals.
2. Redesign the organizational environment, work and rewards. The intent here is to improve the capability of the environment to provide learning and growth opportunities through job rotation, job redesign, and increasing continuing education offerings based on need.

3. Improve understanding of productivity. Comprehending the productivity of the knowledge worker--the engineer or scientist, is one of the most complex tasks.
4. Build self-confidence and understanding. Increasing self understanding makes it possible for the individual to represent himself more effectively at the interface and negotiate for improved congruence between the individual and the organization.

Miller's program represents some of the most advanced applications of the behavioral sciences to the updating process. It should be watched with great interest by all organizations.

Branscomb (1973) describes two key attributes of a vital technical staff member: adventurous and inquiring attitude, and a sense of professional accomplishment. Other indicators of vitality mentioned are: evidence of intellectual competitiveness with peers, professional activity, and publications; self confidence, as evidenced by vigorous, well prepared defense of ideas; willingness to use good ideas of others; willingness by managers to hire and promote young people who are more able than they are; entrepreneurial in spirit and willingness to take risks as evidenced by courage to bootleg projects; to champion unpopular concepts and be willing to do battle with market forecasters for truly new products. A person whose behavior is similar to the ones described above cannot help but keep up-to-date.

Thompson and Dalton (1976) conclude that in technology-based organizations the most critical factor is the development and maintenance of an up-to-date and motivated work force. They recommend three broad areas in which managers can make improvements and thus avoid an obsolete organization:

1. Reward technical contributions by paying for performance, not position; seek inputs in decision making from scientists and engineers; increase the visibility for contributors by giving recognition for accomplishments.
2. Reduce barriers to movement by limiting tenure in supervisory positions; revise cost accounting procedures so that senior people are not excluded by accounting procedures from working on projects using new technologies; more effective use of lateral transfers.
3. Focus on careers: use matrix organization methods to insure career development; provide semiannual manpower review to assess career professionals; and career monitoring to insure new assignments every four years.

A Challenging Job--Its Relation to Updating

Margulies and Raia (1967) asked research and development scientists and engineers, "What was the most fruitful learning experience you have had over the past year or two?" The most frequent response was on-the-job problem

solving (42%). This was described as being assigned to "interesting tasks," "broadening projects," and "writing proposals which force me to dip into the literature and become current on everything connected with the project." When on-the-job activities include challenging assignments, the exploration of new tasks enables scientists and engineers to assess their own knowledge and fill in gaps and deficiencies.

Challenging jobs provide learning experiences that can be interesting, even exciting. They provide experiences of success that play an important role in motivating an individual to keep up-to-date and grow professionally. Responsibility, job involvement, and challenging work assignment all contribute to the first steps in continuing education--awareness of needs and individual motivation.

Pelz and Andrews (1976) reported some findings about scientists and engineers in their job functions. The more kinds of research and development functions the scientist is engaged in, the better his performance. Maximum performance seems to occur with four to five functions. To stimulate updating and build diversified skills in scientific personnel, Pelz and Andrews recommended: "The next time you need to probe a specialized area, give the job to a man (or a small group) who is working in a related area. Don't give the job to a man who already is a specialist in that area. The man in a related specialty will dig into the field with new zest and excitement. He will develop fresh ideas that experts in the area would overlook."

A challenging and meaningful job is critical to keeping the professional updated. However, a number of on-the-job conditions, job pressures, and heavy workload--no time allocated in the daily budget for reading journals, etc.--interfere with the professional's ability to keep current in his field, to

further his education, and to perform his job more adequately. Engineers who work on routine production jobs express the need for more interesting, challenging, and more significant work. In fact, engineers consistently point out that 50-90% of their work is routine and could be more easily done by a technician (Dubin, 1975). Ritti (1971) reported that the lack of opportunity to perform meaningful work is at the root of widespread frustration and dissatisfaction among engineers.

When engineers were asked to describe various aspects of their job, less than 50% of the engineers agreed with the following statements: my job is technically challenging and broadening; my job makes use of my skills; my job measures up to what I want out of a job; and my job forces me to work up to the limits of my ability (Dubin, 1975).

Bray's (1975) study of AT&T managers reports a significant finding. A challenging job is of great importance to maintaining managerial motivation and serious effort should be made to expand the scope of the manager's job to fit his ability. Jobs which provide challenge, a sense of achievement, responsibility, and accomplishment provide a basis for continuous self-development.

Shearer and Steger (1975) tested three hypotheses relating the work experience of engineers and managers to obsolescence. All three hypotheses were positive. They found that varied job assignment provided opportunities to use and maintain previously learned skills and for increasing a person's exposure to new developments and ideas. The second hypothesis stated: the less a person feels he has used his skills, the more obsolescent he is likely to be. Their findings show that the more a person is willing to invest the time and effort to develop new skills, the less likely he is to become obsolescent. The third hypothesis dealt with participation in decision making.

Perceived participation in decision making was found to be the best predictor for keeping current and preventing or retarding obsolescence.

Hackman and Lawler (1971) have utilized job design as a method of enriching jobs. Job design refers to a deliberate purposeful planning of a job, including any and all of its structural or social aspects. Job enrichment attempts to make the job more challenging and interesting, by adding the following dimensions: skill variety; task significance; task identity; autonomy and feedback. A professional is motivated to work more effectively on a job that allows him to feel personally responsible for a portion of the work, provides outcomes that are intrinsically worthwhile, and provides feedback on what is accomplished.

Susman (1974) offers four job enrichment suggestions which can contribute to the reduction of underutilization and misutilization of engineers: the partition of projects into modules of subtasks which represents a psychological whole and a contribution which the engineer can identify with; the use of horizontal rather than vertical decision nodes as a means of introducing greater equality in the decision making process; the authority for the supervisor and his subordinates within each module to make appropriate decisions rather than the project manager who is several levels higher; and allowing engineers to participate in decisions before the final design is approved. Such involvement gives the engineer a larger piece of the action in the organization. His responsibility motivates him to insure that he maintains his competency in his field.

The Supervisor's Role in Updating

The supervisor or technical manager plays a crucial role in the professional development of his subordinates especially in updating, and continuing education. A study by the NSF (1969) found three separate styles of supervision in R&D organizations employing scientists and engineers. The study classified the supervisors by the manner and degree to which they stimulate and attempt to motivate their subordinates to engage in continuing education.

The "Administrator" is seriously concerned with implementing management policy including policy concerned with continuing education, and tries to arouse the interest of subordinates in whatever employer-sponsored activities are provided.

The "Innovator" is vividly aware of the potency of new knowledge and of continuing education and regards these activities as central to his supervision of others. The Innovator is alert to opportunities to create continuing education activities in addition to pushing those sponsored by management. He is sensitive to the continuing education needs of his subordinate and keenly perceptive of the resources available in the wider community, both which do and which don't fit these needs. His enthusiasm for continuing education is such that he will contrive and create both stimulation and utilize such resources as specific workshops, courses or special seminars. He sees these techniques as a way to keep his staff at the frontiers of knowledge by incorporating the latest available knowledge into easily digestible and accessible form.

The "Inactive" type of supervisor is basically passive and non-committal in his attitudes. Because he conceives of self-development (and continuing education) as a responsibility of the employee apart from the working

environment, he neither stimulates subordinates to pursue additional knowledge nor initiates continuing education activities on their behalf. He is aware of, and deplores, the lack of motivation shown by particular individuals, but he undertakes positive action only if the employee takes the initiative and the activity is within the framework of existing policy. He will make pious statements about the desirability of continuing education, but in fact he subscribes a rather fatalistic and resigned view of people and, indeed, of leadership.

Prior to the NSF study quoted above, Dubin and Marlow (1965) reported that 64% of 2,094 engineers indicated that their supervisors took a non-committal attitude towards their education and development. Corroborating evidence of the Dubin and Marlow findings is found in the NSF (1969) study, where almost half of the engineers and approximately one-third of the scientists reported attitudes of non-interest in their professional development by their supervisors. Similarly, 42% of 5,598 natural resource managers and scientists reported that their supervisors were non-committal to their growth and development (George and Dubin, 1971). Landis (1970) in an industrial study of engineers asked, "How does your immediate supervisor feel about further job-directed education and training?" Thirty-seven percent replied, "not encouraging at all"; 47%, "somewhat encouraging;" and 16%, "very encouraging." He concluded that it is the immediate supervisor that counts in the development of subordinates, "If the boss does not encourage a man, he will not take further course work."

Far more serious and frequent are the barriers created by supervisory pressures for immediate results. Daily pressures are stressed to the

exclusion of any ability to concentrate on what may be required for tomorrow. Competence is defined with respect to the present, not the future, so that little if any support is given to self development efforts beyond the employees presently defined technical specialty. Under these working environments, professional obsolescence is virtually certain. Frequently these supervisory practices reflect organizational reward norms, policies to the contrary. Many organizations base rewards on short term results which seem to imply that personal development efforts should occur before joining or at least not on company time (Miller, 1972). These findings would suggest that the pressures of the job as exerted by supervisors may hinder the engineer's self development even if the organization has a policy to provide educational updating.

Most engineers believe that the development of their professional competence, though basically self-motivated, can benefit from the guidance and support provided by experienced and technically competency first-line supervisors. But many engineers believe that management in its policies and priorities does not place a high enough value on professional developments and career goals of its engineers. In terms of performance appraisal, many engineers feel that their supervisors do not give them a detailed performance review on a regularly scheduled basis to discuss with them their specific strengths and weaknesses.

Engineers proposed numerous suggestions on how supervisors can develop and update subordinates: establish good rapport and provide a supportive atmosphere for the group; establish two-way communications; provide feedback on day-to-day performance; do regular and thorough performance appraisal and coaching; shown tolerance of occasional mistakes as part of the learning

process; assign jobs that involve added responsibilities and variety, as well as extends the boundaries of knowledge, technology and experience; provide recognition and reward for superior performance; allow participation by engineers in design decisions; give engineers the authority and respect appropriate to his professional standing (Dubin, 1975).

Pelz and Andrews (1976) report a study of 21 small teams in a NASA research center. They report that human relations skills mattered little. Innovations occurred under supervisors who know the technical details of their subordinate's work, could critically evaluate that work, and could influence work goals.

Colleague Interaction and Updating

A stimulating organizational environment which provides opportunities for peers to interact promotes learning, innovation, and the development of ideas. Learning experiences come from interchange with colleagues, discussion with managers and experts, talking with colleagues from other disciplines, or participating on panels and committees.

Colleague interaction is one of the preferred methods of engineers for gaining needed information. Rosenbloom and Wolek (1970) conducted a study on the flow of technical information in engineering and scientific groups in industrial laboratories. They studied technology transfer--how new knowledge that originates in one place gets communicated and used in another place. They found that most information that engineers in industrial laboratories acquire comes to them by word of mouth from colleagues and local sources.

They described two types of professionals working in laboratories, each with different personal characteristics and sources of information. The

people who use sources outside the laboratories tend to comprise an easily defined group who publish papers, attend professional meetings, have higher education, and work on more basic problems. They belong to professional organizations and report a lot of oral communications with other professionals employed in organizations outside their own. The other group go to meetings less frequently, rarely publish, and get their information by talking to people in their own location. A person in this group talks to the boss, the man in the next department, to marketing people, and production people. He keeps up-to-date by talking to people in other divisions in his company and by reading trade magazines. The existence of an organizational climate that encourages interaction among colleagues, superiors and subordinates, cannot be overstated for this group. Much learning occurs through informal discussion and consultations.

In the acquisition and transfer of knowledge Rosenbloom and Wolek (1970) report two different modes: the use of interpersonal relationships between knowledgeable persons and the use of professional literature. Engineers rely heavily on interpersonal communication with people in other parts of their own corporation while interpersonal communication by scientists tend to be with individuals employed outside their own corporation. When using documents engineers tend to consult reports in trade publications, while scientists make greater use of professional literature and written sources of information.

Colleagues are important sources of information. Often the most up-to-date information is available from fellow engineers. In a large organization young engineers initially seek out a mentor in a more experienced engineer.

Co-workers are sources for answers to emergency questions. Face to face discussions are considered by engineers to be more productive and speedier than searches of the literature. Colleagues trade information, questions and answers freely. They teach each other, exchange tips and suggest warnings about pitfalls which may be encountered on certain kinds of assignments (Dubin, 1975).

Engineers and scientists look to their colleagues within their working unit for approval and recognition for a job well done, especially if this recognition is not forthcoming from the immediate supervisor or higher management. They are motivated by the desire for approval of their peers and to keep up with their peers.

The degree of interaction and communication among colleagues was vividly described by one engineer, "We are constantly moving in interlocking circles." The chief complaint that engineers have in respect to their colleagues in the job is that they do not have enough time for job related discussions with their peers. More than 75% of engineers responded affirmatively to each of the following questions:

Agree that engineers have the opportunity to discuss technical and other problems with colleagues on the job.

Agree that colleagues on the job help to identify pertinent sources of information.

Agree that colleagues assist the engineer in approaching and understanding a problem better.

Agree that colleagues provide the engineer with information on what approaches have been tried by others and what results have been obtained.

Agree that colleagues can help an engineer to confirm the best approach and improve his ability to decide on a problem (Dubin, 1975).

Pelz and Andrews (1976) found a positive relationship between colleague contacts and performance even when differences in experience, supervisory status, are taken into account. How can colleagues enhance performance? "One way is by providing new ideas--jostling a man of his old ways of thinking about things. But colleagues may do much more. Sometimes a colleague may know something another man needs to know."

"Then there is the possibility of a colleague catching an error which the man himself is too engrossed to see. Still another way colleague contacts may help in keeping the engineer and scientist on his toes--like providing some friendly but real competition for promotion or recognition. Frequent contacts with many colleagues seem more beneficial than frequent contacts with a few colleagues. Similarly, having many colleagues both inside and outside one's own group seemed better than having many colleagues in one place and just a few in the other. Set up teams, committee evaluation groups, lunch gatherings, but keep the situation loose. After all, the goal is good communication between individual men, not a complicated or rigid set of formal meetings. One important thing that you can do is to make sure that

men working in related areas are aware of each other's activities, interests, and problems. If this condition is met, your men can themselves see the contact which promise to be useful."

In short, contacts with colleagues provide intellectual stimulation, new ideas, a lot of error catching, coordination, and even some needed relaxation. These are the kinds of activities that foster updating.

Schwartz, Goldhar, and Gambino (1976) report some interesting ideas regarding the nature, source and flow of important information used by innovators in the chemical industry. A large number stated that the open literature was their most important source of information. Yet a surprising 80% got their important information by listening, not reading; and a third reported that the key information was readily available in the industry. Second, internal sources are much more fruitful than external. Finally, informal communications channels are three times more commonly use than formal ones.

The updating process which we have been examining is necessary and complex. It requires the combined forces of individual motivation and organizational support. The common goal is to preserve and promote one of our most valuable resources--the talents of highly qualified engineers and scientists.

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APPENDIX I

Continuing Education Policy Statement

Sandia Laboratories supports and encourages, as a matter of Company policy, continuing education that assists both the individual employee and the organization to overcome obsolescence, prevent obsolescence, and build for future competency.

The Company realizes that technical obsolescence is not an all-or-nothing proposition. It is a relative process, with the degree of obsolescence being a function of new knowledge and new techniques along with work pressures, specialization, and lack of opportunity to use certain skills and knowledge. Sandia Laboratories, consequently, recognizes that there is a mutual responsibility to be shared by the Company and by the employee for activities that tend to overcome and prevent obsolescence. It is the feeling of top management that continuing education contributes significantly to maintaining a high quality staff.

Sandia Laboratories, through the leadership of its management, desires to maintain an organizational climate that tends:

1. to develop a strong sense of purpose and direction on the part of the employee toward his own development on the job and his responsibility for the job,
2. to stimulate the employee to use his own initiative, innovative talent, and creative ability past fulfilling management expectations of what should be done on the job, and
3. to encourage the employee to use his time, energy, and abilities not only to carry out present assignments but to do some critical thinking about possible new assignments.

To enhance the possibilities of attaining such a climate, the management feels that the organization should support and encourage continuing education activities of its employees:

1. to achieve specialization or acquire capability in particular disciplines, new fields, or techniques,
2. to make progress in their job situation by acquiring knowledge needed as a basis for progress as part of the job time,
3. to take advantage of refresher and updating opportunities in order to maintain them at a high level of work performance,
4. to reorient themselves in mid-career according to their own needs and the needs of the company, and

5. to keep up-to-date by providing opportunities to attend technical and professional meetings, publish papers, participate actively in technical societies, and other ways of keeping in touch with the world of science outside the Laboratories.

Stimulating subordinates to participate in activities which keep them up-to-date is an integral part of the supervisor's job. Supervisors are encouraged to discuss continuing education needs with each subordinate and to devise plans for meeting these needs.